STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF UNDERGROUND STORAGE TANKS
TECHNICAL GUIDANCE DOCUMENT - 016
EFFECTIVE DATE - AUGUST 1, 1996

RE: Mobile Enhanced Multi-phase Extraction

The purpose of this document is to provide guidance for applying enhanced multi-phase extraction technology at petroleum underground storage tank sites. Mobile Enhanced Multi-phase Extraction (MEME), also known as dual-phase extraction or vacuum-enhanced extraction, is a cost effective, in-situ technology that utilizes high vacuum pressures and air flow rates. The goal of MEME is to remove vapor, adsorbed, dissolved and free phase volatile organic compounds from the saturated and unsaturated zones. This is most commonly done by using a mobile unit containing a high capacity vacuum pump. MEME may also introduce oxygen to the subsurface to enhance natural biodegradation. Mobile Enhanced Multi-phase Extraction may be applicable at petroleum UST sites to meet the following objectives:

- initial abatement,
- free product removal, or
- reducing levels of dissolved petroleum constituents in soil and ground water.

I. Application and Cost Proposal

A. Complete the following:

1. Application to Perform Mobile Enhanced Multi-phase Extraction (Attachment A)
2. Cost Proposal for Mobile Enhanced Multi-phase Extraction (Attachment B)

B. Submit the completed application and cost proposal to the appropriate Division of Underground Storage Tanks field office for approval (with a copy to the central office) **before** performing the MEME event.

II. Field Monitoring

Complete the Field Monitoring Log as instructed in Attachment C. During the MEME event, the parameters on the log shall be monitored at fifteen (15) minute intervals for the first two (2) hours, and at thirty (30) minute intervals thereafter. The concentration (emission) readings shall be collected from the system outlet (stack) using a flame ionization detector (FID), thermal conductivity meter or other instrument approved by the Division. All instruments must be equipped with a condensate trap capable of removing moisture. The air flow shall be measured using a device capable of measuring velocity to +/- 5%. Vacuum readings on surrounding monitoring wells shall be recorded to determine the radius of influence. At a minimum, water level readings in the surrounded monitoring wells shall be taken before and after the event.

III. Reporting Requirements

A cover sheet, summarizing the event, shall be prepared and submitted with the completed MEME Field Monitoring Log. This information must include an explanation of the disposition of the extracted fluids. This document shall be submitted within 20 days of the event.

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Attachment A

Application to Perform Mobile Enhanced Multi-Phase Extraction (MEME)

Submit the **original** of this application to the appropriate Division of Underground Storage Tanks field office for approval **before** performing a MEME event. Attach extra sheets if necessary.

1. Date: _____

2. Facility I.D. Number: _____

3. Facility Name: _____

   Facility Address: _____

   _____

   _____

4. Facility Telephone Number: (_____) _____

5. Name of UST System Owner: _____

   Owner Address: _____

   _____

   _____

   _____

   _____

   Owner Telephone Number: (_____) _____

6. Type of Contaminant: _____

7. Number, Date and Length of Events Requested: _____

   _____

   _____

   _____

   _____

8. If the information is available, provide a table showing the contamination levels in each well. Provide a site map showing the locations of the monitoring wells if this information has not been previously submitted.

9. OBJECTIVE: State the purpose and reasoning for the event(s).

10. List monitoring wells to be used for extraction:

11. List the order and configuration of the extraction wells:

12. Describe the method for determining the vacuum radius of influence:

13. Describe your contingency plans if the wells do not react as predicted:

14. Describe the safeguards for insuring contamination will not spread onsite or be drawn from offsite:

15. Equipment to accomplish the objective.

Type of pump: _____

Horsepower: _____

Vacuum capacity (inches of Hg):_____

CFM capability:_____

16. Provide a diagram detailing the configuration of the wellhead and downhole extraction equipment.

17. Describe the instruments for measuring stack velocities and vapor concentration levels.

_____

_____

_____

_____

_____

_____

18. Describe the calibration procedures for the instruments listed:

_____

_____

_____

_____

_____

_____

_____

_____

_____

19. List the personnel that will be at the site, their job title and anticipated time at the site:

Name	Title	Time On-site

20. Describe the disposal method for the extracted fluids.

_____

_____

_____

_____

_____

Attachment B

Instructions for Cost Proposal for Mobile Enhanced Multi-phase Extraction

Section 1. Field Equipment

This section includes all on-site equipment used for petroleum hydrocarbon extraction and monitoring. Description of equipment should include type, size and brand, whenever possible. Please quote the unit rate and the number of units (hours/day) to be used per event. Extend these to the equipment cost column. Also include mobe/demobe cost of equipment and total all equipment costs.

Section 2. Field Personnel

List all personnel involved with on-site extraction and monitoring. Include name, billing title, description of duties, hourly rate and unit of hours on site. Extend all cost to the personnel cost column. Also include any mileage and per diem relating to these individuals. Total all lines for field personnel, mileage and per diem and record in the proper space provided.

Section 3. Project Management & Report Preparation

List personnel involved with managing the extraction event and preparing the report. Include name, billing title, description of duties, hourly rate and unit of hours on site. Extend all cost to the personnel cost column. Total all personnel cost and record in the proper space provided.

Section 4. Hauling and Disposal

This section includes the cost of the disposal of extracted fluids. If transported to a water treatment facility, include the unit cost and the number of units in gallons. Also include any charges relating to hauling the extracted fluids.

Section 5. Total cost for one Multi-phase Extraction Event

Add totals of Sections 1-4 and record in this section. Please double check all math.

Attachment C

Measurements recorded on the attached MEME Field Monitoring Log shall be taken every fifteen (15) minutes for the first two (2) hours, and every thirty (30) minutes thereafter. Field monitoring associated with TGD-016 shall include the following parameters:

1. Event date
2. Event number
3. Facility Name
4. Facility address
5. UST Facility ID number
6. Consultant name
7. Monitoring interval time
8. Extraction well number(s)
9. Vacuum measurements in inches of mercury for each extraction well per time interval
10. Air flow velocity in feet per second at system outlet (stack) per time interval
11. Total flow reported as Dry Standand Cubic Feet per Minute. **(See EQUATIONS)**
12. Temperature of stack gas at system outlet (stack) per time interval
13. Stack emission readings in parts per million (PPMv) per time interval
14. Pounds of carbon, removed per time interval **(See EQUATIONS)**
15. Monitoring well number
16. Depth to water (DTW) before the event
17. Depth to product (DTP) before the event
18. Product thickness, in feet, before the event
19. Depth to water (DTW) after the event
20. Depth to product (DTP) after the event
21. Product thickness, in feet, after the event
22. Comments
23. Personnel onsite during the MEME event
24. Stack Diameter (Inside Diameter)
25 Type of calibration gas used
26. Total gallons of water removed during the event
27. Cumulative gallons of water removed to date
28. Total pounds of carbon removed during this event
29. Cumlative pounds of carbon removed to date
30. Total time of event

Periodic adjustments shall be made to insure maximum recovery of hydrocarbons. Any changes or adjustments performed in the field during the MEME event shall be documented in the comments section on the MEME Field Monitoring Log.

EQUATIONS

Equation to determine flow as Dry Standard Cubic Feet Per Minute (DSCFM):

$$Q_{std} = (60 \text{ sec/min}) (1-B_{ws}) (V) (A) (528 R^o / T_s)$$

Q_{std} = flow at DSCFM

B_{ws} = water vapor % by volume, high temp. psychrometric chart for air-water vapor mixtures in *Perry's Chemical Engineers' Handbook*, assume stack gas is saturated

V = velocity in ft/sec, obtain with hot wire anenometer or pitot tube

A = cross sectional area of discharge stack in sq.ft. at sampling location

T_s = stack temperature in degrees Rankin (R^o), $R^o = F^o + 460$

Equations to determine pollutant mass removal rate as carbon (PMR_c):

$$PPM_c = (PPM_{meas})(K)$$

$$C_{c:m} = PPM_c (M_c / K_3)$$

$$C_c = C_{c:m} (62.43 \times 10^{-9} \text{ lb-m}^3/\text{mg-ft}^3)$$

$$PMR_c = C_c (Q_{std}) (60 \text{ min/hr})$$

PPM_{meas} = obtained directly from instrument

K = number of carbons in calibration gas, methane, K = 1
propane, K = 3
hexane, K = 6

$C_{c:m}$ = mg/dsm^3, mass concentration of Total Gaseous Nonmethane Organic (TGNMO) emissions

PPM_c = PPMv, volumetric concentration of TGNMO emissions as carbon, dry basis, at STP

M_c = 12.01 mg/mg-mole, molecular weight of carbon

K_3 = 24.07 $dsm^3/10^6$ mg-mole, mass to volume conversion factor at STP

C_c = lb/dscf, mass concentration of TGNMO emissions as carbon, dry basis, at STP

PMR_c = lb/hr, pollutant mass removal rate of TGNMO emissions

MEME FIELD MONITORING LOG

1. Date:	3. Facility Name:	5. Facility ID #:
2. Event #:	4. Facility Address:	6. Consultant:

7. Time	8. Extraction Wells	11. Vacuum (in/ Hg) At Extraction Well Head				10. Velocity in Feet per Second	11. Total Flow as DSCFM	12. Temp. of stack gas	13. Conc. in PPMv	14. Pounds of Carbon Removed
		Well #	Well #	Well #	Well #					
								Total lbs. Removed		

	Before Event			After Event		
15. Well #	16. DTW	17. DTP	18. Prod. (ft)	19. DTW	20. DTP	21. Prod (ft)

22. Comments:	23. Personnel:
	24. Stack Diameter I.D.:
	25. Calibration Gas:
	26. Total Gal. of Water:
	27. Cum. Gal. of Water:
	28. Total lbs. of Carbon this event:
	29. Cum. lbs of Carbon removed:
	30. Total hours of event: